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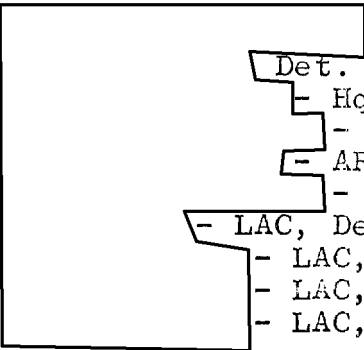
9 October 1968

MEMORANDUM FOR THE RECORD

SUBJECT: U-2R LOX System Meetings and Status as of
3 October 1968

1. An initial meeting on LOX system problems and courses of action required to resolve these problems was held at Detachment G on 30 September 1968. Attendees were:

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- Det. G, DM
- Det. G, Life Support
- Hq, Life Support
- ARO Corp.
- ARO Corp.
- LAC, Flight Test
- LAC, Design
- LAC, Design
- LAC, Maint. Manuals
- LAC, Maint. Manuals

The specific subjects discussed and proposed actions were as follows:

USAF
review(s)
completed.

a. High Pressures: ARO representatives stated that high operating pressures (above 100 psi) indicated on the pressure gage, that will not fall to and remain in the normal range (60 to 90 psi) upon drawing a flow at the cockpit (70 LPM for 30 seconds), indicate a condition referred to as "LOX saturation". This condition, which occurs when LOX is kept in a converter in the "build-up" position for long periods of time (beyond 24 hours), can lead to excessive oxygen loss via the pressure relief valve. The two methods for preventing LOX saturation are to either leave the system in the "Vent" position except when actually required to be in build-up for flight, or to insure that the converters are "topped-off" with fresh LOX close to flight time. Since LAC opposed leaving the system in vent, due to possible contamination entering the vent line (a possibility that has not been confirmed to date), it was decided that all Detachment aircraft would remain in the "build-up" position and be serviced with fresh LOX between 1 and 8 hours prior to every flight. LAC stated that flight test would

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attempt to determine if saturation did in fact lead to excessive pressures and quantity loss by tests using Aircraft 051.

b. Abnormal Operation: Since all system components are standard items used throughout the USAF with great reliability, hardware design was not felt to be the cause of our LOX problems. Contamination was felt to be the cause of most past problems. It was concluded therefore that the first course of action on abnormalities that are obviously not a failed component would be purging of the oxygen system.

c. Purging. The basic USAF oxygen equipment technical order (T.O. 15 X-1-1) specifies the use of hot oxygen purge procedures. The existing purge procedure for the U-2R (from the maintenance manual) was inadequate since cold oxygen was utilized. LAC was to determine if hot oxygen purging (250°F max.) would adversely affect any component of the system while ARO was to provide information regarding purge kits. The undersigned stated that the pressures and durations specified in the U-2R maintenance manual would suffice only if hot purging was adopted.

d. Purge Frequency. Since contamination can only enter, on a routine basis, during LOX filling operations, it was agreed that 25 servicings (fillings) would be the limit between purges.

e. Plumbing Changes. To reduce the chance of moisture collecting at or near the relief valves and to assist in trouble-shooting the system, the lines from the relief valves will be separated from the vent lines and routed to their own overboard fitting.

f. Preflight Tests. ARO recommended that preflight flowmeter tests of the vent/relief valves at the overboard fitting be included to detect potential problems.

2. A second meeting was held late on 2 October 1968 to review data collected and results of investigations conducted since the 30 September meeting. Attendees at the

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second meeting were as follows:

- Det G, DM
- Det G, Life Support
- Hqs, Life Support
- Det G, Life Support
- ARO Corp.
- ARO Corp.
- LAC, Flight Test
- LAC, Design

The results of this meeting were as follows:

a. Interval Between Filling and Flight.

[redacted] stated that no LOX problems occurred since Monday's meeting, but that servicing LOX between 1 and 8 hours prior to flight necessitated bringing in his maintenance crew 30 minutes earlier in the morning. He stated that he had previously objected to leaving the LOX system in build-up and servicing shortly before flight because of this maintenance manpower problem. He had preferred topping off the LOX system when it came back from a flight and then leaving it in vent until time for the next flight, with no specified time interval between filling and flight. He also stated that he would prefer to have the systems in vent while in the hanger for safety reasons (i.e., zero pressure in systems). [redacted] then discussed their findings from tests conducted with Aircraft 051 between Sunday, 29 September and Wednesday, 2 October, during which period both systems remained in build-up and neither had received fresh LOX. The aircraft had been flown daily, allegedly without preflight flows being drawn to lower the system pressure. In this period there were no excessive quantity losses either on the ground or in-flight. LAC therefore recommended that the maximum allowable interval between filling and flight be increased from 8 hours (as agreed to on 30 Sept.) to 24 hours. [redacted] stated this would be more acceptable and the average time between filling and flight would probably work out to be between 15 and 18 hours. This extension was therefore adopted for all detachment aircraft and the systems will be closely monitored for approximately 3 weeks. At the end of this period LAC and detachment representatives will again meet to finalize all procedures and have them incorporated into appropriate U-2R maintenance manuals. 051 will continue to be used and quantity loss.

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b. Aircraft 052 Tests. It was decided that an extended test would be conducted using Aircraft 052, to determine the differences, if any, between leaving the LOX system in build-up or in vent. Both systems would start out with draining, a hot oxygen purge, refilling and checkout. System #1 would then be kept in the vent condition except for flight, while System #2 would be kept in build-up at all times. Both systems would be filled within the 24 hour maximum allowable interval prior to flight. Detachment G life support personnel were charged with the monitoring of Aircraft 052 and the recording of all data collected for the test period. The test period will cover the time between normal purges (i.e., 25 fillings).

c. Purging Procedures. Hot oxygen purging was accepted by all representatives as the only acceptable method. LAC representatives stated that none of the system components would be adversely affected by hot oxygen. ARO representatives stated that their purge kit, which Detachment G life support has four of, is built to the same military specification as the purge kit referred to in the basic oxygen technical order (T.O. 15 X-1-1). The military specification of concern is MIL-P-27431A. The purge kit meeting this specification operates at an inlet pressure of 50 to 500 psi, connects to a 115V, 60 or 400 cycle power source, with an outlet flow of 65 ± 5 SLPM at a temperature of $235 \pm 15^\circ\text{F}$. The total minimum purging duration for each system is to be 97 minutes. The exact procedures (i.e., inlet pressures and flows) were to be determined during the initial purging of Aircraft 052 on 3 Oct 1968. Aircraft 057 and 058, scheduled for SWAP SHOP, were to receive hot purges as soon as they could be scheduled.

d. Plumbing Changes. LAC will work up and submit a service bulletin for approval to make the necessary plumbing changes to separate the relief valves overboard vent from the vent valves overboard vent.

3. Summary and Conclusions:

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- a. If contamination (moisture or other) was the cause of all previous problems, then the incorporation of a more adequate purging procedure and extreme care during the filling operation (i.e., insuring fill valves are free of contamination, purging filler hose, etc.), should eliminate such problems.
- b. Occasional component malfunctions or failures, unrelated to contamination, can be expected, but adequate preflight and/or trouble-shooting procedures should readily identify such problems.
- c. High operating pressures in flight (i.e., from 100 to 120 psi) do not represent a problem per se, since all components including the pilot's breathing regulators will function at such pressures. However, additional factors enter the consideration at this point, as follows:

(1) High Pressure with Excessive Quantity Loss:

In several past incidents, high operating pressures have been associated with excessive quantity loss either during flight or while the aircraft was on the ground. LAC contends that the excessive loss is not directly related to high pressure but is due to a component malfunction (contamination or failure). ARO contends that high quantity losses can be expected when a system has reached LOX saturation, since the relatively warmer LOX continues to generate high pressure gas and keeps the relief valve open for extended periods. Such a condition is aggravated by vibration of the converters. In either case the recently adopted procedures should eliminate this problem area. If the problem occurs again, it may indicate saturation is occurring when the maximum allowable time between filling and flight is used (i.e., 24 hours). If a pilot notes high operating pressure (one or both systems) in flight, he should note quantity at regular intervals for excessive loss.

(2) Uneven Feeding. Because the pressure suit breathing regulator tilt valves are of a pressure closing design (i.e., fail safe to prevent 70 psi from entering helmet), the regulator with the lowest input pressure will generally tend to

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supply the pilot's breathing demands. If there is a wide variation between System #1 and System #2 operating pressures, the quantity in the system with lower pressure will fall with use, while the quantity in the high pressure system will fall very little. In a redundant system this has little significance except perhaps psychological. The concern of a pilot might be that in using one system at a time, a failure halfway through a flight of the high pressure system would leave him not only without redundancy but with low quantity in his working system. However, if the flight was started with both converters full (i.e., 9 to 10 liters), either system alone would provide oxygen for a duration of nearly 17 hours at altitude. If both systems are operating at nearly the same pressure, in the normal range, uneven feeding will be eliminated and both systems will deplete at a nearly even rate. The only danger of uneven feeding would be if the high pressure system, which was not feeding, suddenly started to lose excessive quantity due to relief valve venting. The pilot could then end up with low quantities in both systems. Again, the recently adopted procedures should eliminate this area of concern by preventing LOX saturation and/or quantity loss due to contamination caused malfunctions.

d. Adequacy of the heat exchanger/supply tubing length may require further consideration if transient low pressures continue to be experienced in flight. If such problems have occurred because of contamination, they should no longer be encountered. If they are experienced despite improved servicing/purging procedures, the relationship of breathing demands to gaseous supply capability (i.e., heat exchanger/supply tubing related) will require further study. The undersigned is attempting to research appropriate guidelines, specifications, and reports for guidance while ARO Corp. representatives are planning on performing in-house testing related to this question.

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